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(71) Applicant: MOTOROLA INC. [US/US]; 1303 East Algonquin Road, Schaumburg, IL 60196 (US).

(72) Inventors: GOEDKEN, James, Francis; 55 South Vail #1212, Arlington Heights, IL 60005 (US). PERSZYK, Thomas; 192 Jefferson Lane, Bloomingdale, IL 60108 (US). MALEK, Charles, John; 915 Camelot Drive, Crystal Lake, IL 60014 (US).

(74) Agents: PARMELEE, Steven, G. et al.; Motorola, Inc., Intellectual Property Dept./JJK, 1303 East Algonquin Road, Schaumburg, IL 60196 (US).

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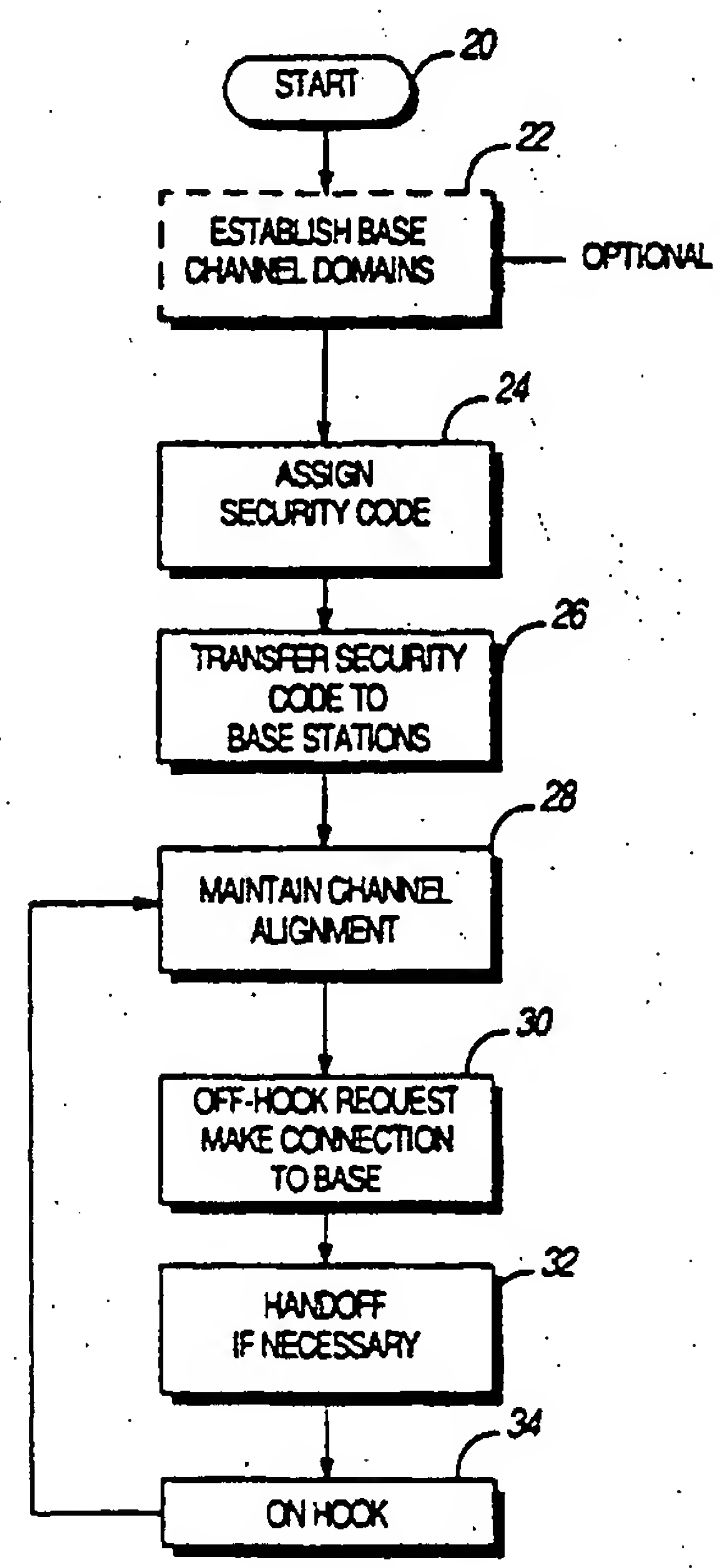
(57) Abstract

The present invention encompasses a method for establishing and maintaining communication in a portable telephone system adapted to operate with a plurality of base stations and at least one handset on a plurality of channels. The method generally includes steps of assigning a security code to the handset(s) operating in the portable communication system to enable RF communication between the handset(s) and the plurality of base stations (24); communicating the security code assigned to the handset(s) to the plurality of base stations to maintain within each of the plurality of base stations the security code(s) of the handset(s) operating in the system (26); and aligning the channel of the handset(s) with a channel of a base station to allow for communication between each handset and one of the plurality of base stations (28).



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METHOD FOR OPERATING A COMMUNICATION SYSTEM HAVING MULTIPLE BASE STATIONS

Field of the Invention

The present invention is generally related to communication systems, and more particularly to a method for operating a wireless communication system having multiple base stations.

Background of the Invention

Previously, wireless communication systems providing communication between one or more remote devices and a plurality of remote base stations included a controller to regulate the communication between a remote device and the base stations. The controller would generally provide the hand-off between the base stations when necessary. One example of a wireless communication system having a number of base stations is a cellular telephone system. Generally, the base stations of the cellular telephone system are controlled by a cellular control station.

A cordless telephone system is another example of wireless communication system which could operate with a plurality of base stations. Typically, cordless telephone systems include one or more wireless remote devices or handsets which are associated with a single base station. Each of the handsets may communicate with the base station on a different frequency. Therefore, communication between the multiple handsets and the single base station can be accommodated.

In a cordless telephone system having multiple base stations, it is necessary to allow the handset to communicate with each base station, while preventing unauthorized handsets from communicating with the base stations. Accordingly, there is a need to assign security codes to each handset and maintain a list

of the security codes of all active handsets allowed to operate in the system. Further, when a handset is waiting to communicate with a base station, the handset should be on the same channel as a base station within range to reduce the amount of time necessary to provide a radio frequency (RF) communication link between the handset and a base station. Accordingly, there is a need to align the channel of the handset to a base station which is within range even when the handset is not communicating with a base station.

Also, because the strength of the RF communication signals between the handset and the base stations may vary with the relative location of the handset to the base stations when the handset is communicating with a base station, it is useful to provide an RF communication link between each handset and a base station which has the strongest RF communication link. Accordingly, there is a need to transfer the communication signals between base stations in a wireless communication system having multiple base station.

As in any wireless communication system having multiple base stations, there is a need to regulate the communication between a handset and the base stations. In particular, there is a need for regulating which base station will communicate with a particular handset. It is beneficial to regulate communication between a handset and the base stations without employing a separate controller of the base stations. Eliminating any requirement for separate controller will reduce both the cost and complexity of the system. Accordingly, there is a need for a method for operating a wireless communication system having multiple base stations such as a cordless telephone system which eliminates any requirement for a separate controller of the base stations.

Summary of the Invention

The present invention encompasses a method for establishing and maintaining communication in a portable telephone system adapted to operate with a plurality of base stations and at least one handset on a plurality of channels. The method generally includes steps of assigning a security code to the handset(s) operating in the portable communication system to enable RF communication between the handset(s) and the plurality of base stations; communicating the security code assigned to the handset(s) to the plurality of base stations to maintain within each of the plurality of base stations the security code(s) of the handset(s) operating in the system; and aligning the channel of the handset(s) with a channel of a base station to allow for communication between each handset and one of the plurality of base stations.

In another aspect, the present invention discloses a method for assigning security codes for a portable communication system adapted to operate with a plurality of handsets and at least one base station. The method comprises the steps of providing the current security code of each of the handsets to the base station; assigning a new security code to each of the handsets; and placing each new security code on the master list of security codes in the base station.

The present invention further discloses a method for maintaining communication between a handset and one of a plurality of base stations when the handset is not actively communicating with a base station. In one aspect of the invention, a method comprises, for each handset, the steps of periodically sending a handshake request from the handset to the plurality of base stations; waiting for a return handshake from a base station; and changing the channel of the handset to correspond with the channel of the base station which returned the handshake.

Finally, in another aspect of the invention, a method for maintaining communication in a portable communication system having a plurality of base stations and at least one handset when a handset is actively communicating with a base station is disclosed. In particular, the method includes steps of evaluating the RSSI level of a signal received at a base station from a handset; instructing remaining base stations to report an RSSI level and an operating channel; selecting the base station reporting the strongest RSSI signal; instructing the handset to switch to the operating channel; and providing a handshake between the handset and the base station reporting the strongest RSSI signal.

In an alternate embodiment of a method for maintaining communication in a portable communication system having a plurality of base stations and at least one handset when a handset is actively communicating with a base station, the method comprises the steps of evaluating the RSSI level of the signal received at a base station from a handset; placing the base station on hold; the handset requesting to make a connection to the base station reporting the strongest RSSI signal; providing a handshake between the handset and the base station reporting the strongest RSSI signal.

Brief Description of the Drawings

In describing the present invention, reference is made to the following drawings wherein:

FIG. 1 is a plan view of a conventional wireless communication system having multiple base stations and multiple wireless handsets employing the method of the present invention;

FIG. 2 is a flow chart of the method for operating a communication system having multiple base stations according to the present invention;

FIG. 3 is a flow chart of a method for transferring security codes between base stations according to the present invention;

FIG. 4 is a flow chart of a method for maintaining a channel alignment between base stations and handsets according to the present invention;

FIG. 5 is a flow chart of a method for establishing an offhook condition of a handset according to the present invention;

FIG. 6 is a flow chart of a method for executing a handoff between base stations according to the present invention; and

FIG. 7 is a flow chart of an alternate method for executing a handoff between base stations according to the present invention.

FIG. 8 is a block diagram of the preferred circuit for operating a wireless communication system according to the present invention.

FIG. 9 is a circuit diagram of the preferred signal transceiver circuit shown in the block diagram of FIG. 8.

Description of the Preferred Embodiment

Referring to FIG. 1, a plan view of a wireless communication system 10 having a plurality of base stations 11 and a plurality of handsets 12 employing the circuit and method of the present invention is shown. Base stations 11 are coupled by a data link 14 to a single line 16 of a public system telephone network (PSTN) 18, although the method of the present invention could be employed on a system of base stations coupled to multiple phone lines. While any number of handsets 12 could be incorporated in the wireless communication system, only one handset is required. Handsets 12 could include any device capable of RF communication with base stations 11. An example of a base station and an associated handset includes a cordless telephone. A cordless telephone which could employ the method of the present invention is disclosed in US Patent No. 5,140,635, assigned to Motorola, Inc., the entire patent of which is incorporated by reference.

As shown in FIG. 1, each base station 11 is in communication with the other base stations by way of data link 14 (indicated by the solid lines between the base stations). Preferably, the data link could incorporate the standard ring and tip lines of the public system telephone network by coupling each base station to the same telephone line 16 of the public system telephone network. Alternatively, the communication between the base stations could be accomplished by RF communication or over an AC power line. Finally, each handset 12 communicates with each base station 11 by way of RF communication signals (shown by the broken lines in FIG. 1).

Turning now to FIG. 2, a flow chart shows the preferred method for operating a communication system having multiple base stations according to the present invention. To avoid interference between base stations in a multibase system, each base station is preferably restricted to a certain subset of the total

available channels. For example, in a frequency division multiple access (FDMA) 49 Megahertz cordless system, there are presently a total of ten channels available for use. In a system having two base stations, a first base station may be assigned channels 1-5 and a second base station may be assigned channels 6-10. Preferably, the channels assigned to a single base station are not adjacent frequencies in the spectrum. Base stations always communicate within their channel domain, except when asked to report their RSSI level on a specific channel for handoff purposes, discussed infra.

In assigning the channel domains for the base stations, it is preferred that no two base stations that could ever be in the RF range of the same handset may have intersecting channel domains. That is, while the RF range of the base stations intersect to provide seamless handoff, it is preferred that the base stations which have intersecting RF ranges do not have intersecting RF channel domains. Accordingly, if there are less base stations than total available channels, it is possible to ensure that no two domains intersect by exclusively assigning channels to base stations. Therefore, the base stations may be placed wherever they are desired. It should be noted that if there are less base stations than available channels, the base stations could have overlapping channel domains if the base stations are carefully placed to avoid channels having overlapping channel domains being in the same RF range. However, if a system has more base stations than available channels, care must be taken as to the positioning of base stations having intersecting channel domains.

There are a number of ways to implement domain assignments for the base stations according to the present invention. The channel assignments could be manually assigned by using the keypad of the base station to select channels. Alternatively, the base stations could be preprogrammed at the time of manufacture. Finally, the base stations may be allowed to arbitrate with each other to ensure their non-simultaneous use of

RF channels when the base stations have overlapping radii of RF coverage, and when the bases are within range of a specific remote device. There are a number of ways to arbitrate. For example, the base stations could arbitrate by RF communication when idle or add a separate RF transceiver for arbitration. Alternatively, the bases could arbitrate over the AC power line or the PSTN. Arbitration would allow bases that are servicing a handset to scan all available (i.e. all 10) RF channels, either automatically or by user request. If a base required the use of a channel outside of its normal channel domain, and that channel was not currently in use, it could simply trade with the base station assigned that channel. This could be done in real time, giving the user access to all available channels.

To avoid interference from bases outside the multi base system (e.g. a neighbor's phone), bases that are not servicing a handset periodically check their RSSI levels to see if a potential interferer exists. If so, the base scans for a clean or unoccupied channel within its domain. Alternatively, the base station could trade if necessary to moves to the unoccupied channel. Then when a handset scanning for a base moves into that bases domain, it is likely that the connection will be established on an unoccupied channel, without requiring any communication on a occupied channel.

Having established the base station channel domains, security codes can be assigned to the handsets at a step 24. Generally, security codes are assigned to ensure that only handsets which are a part of the system are allowed to communicate with the base stations of the system. Accordingly, a handset associated with foreign base station in the proximity of one of the user's base stations will not be allowed to communicate with the user's base station. Preferably, the security code assigned to each handset can be assigned when the handset is cradled in the base station. The assignment of security codes can be accomplished by way of a physical connection between the handset and the base station. However, it is

possible to assign security codes by way of RF communication signals. For additional security, an access code may be required by the user before a security code can be assigned to a handset

The security code assigned to any given handset by a base station must be communicated to the remaining base stations in the system at a step 26 to allow the handset to communicate with any of the base stations in the system. Preferably, the security codes assigned to the handsets can be transferred between the base stations by way of a data link, such as that disclosed in a U.S. Application invented by James Mielke and entitled "CIRCUIT AND METHOD FOR OPERATING A WIRELESS COMMUNICATION SYSTEM" (attorney docket number CE00811R), such application being assigned to the assignee of the present invention and filed on even date herewith. The aforementioned application generally discloses a method and circuit for transferring security codes as 30 KHz signal on a datalink coupled to the telco line. The circuit is described in detail in reference to FIGS. 8 and 9. Alternatively, the security codes could be preprogrammed at the time of manufacture, manually programmed using the base and/or handset keypads, or randomly generated once (or multiple times via user request) by the handset and then transferred to each base by a one time physical connection (i.e. through the charge contacts). This would eliminate the need for base to base communication, thereby reducing the cost and complexity of the system.

At a step 28, the base stations maintain a channel alignment with the handsets to ensure that an RF communication link can be established between each handset and a base station. Generally, each handset will periodically request for a handshake with a base station via the RF communication link on a designated channel. If the handshake request is unsuccessful, the handset will continue to request a handshake on different channels until it receives an acknowledge from a base station. Accordingly, in response to a ringing signal or when the handset

goes offhook to initiate a call, the handset will be on an unused channel associated with a base station which is within range of the handset. Although channel alignment is beneficial in a system having a single base station, maintaining channel alignment is particularly important in system having multiple base stations. When a handset which is moved within the area covered by the base stations, the handset will be able to communicate on an unoccupied channel with one of the base stations within range.

An offhook request to make communication with a base station is then made at a step 30. The offhook request could be made in response to a ringing signal, or when placing an outgoing call. After a connection is made with a base station, the RF communication link is maintained with the base station until a handoff is required at a step 32. A handoff may be necessary when the user of the handset travels within the region of the base stations. The user may travel outside the range of one base station and within the range of another base station, requiring a handoff to the other base station. At the end of a conversation, the handset will go onhook at a step 34. After going onhook, the handset will maintain a channel alignment with the base stations as described in reference to step 28.

Turning now to FIG. 3, a detailed flow chart showing the preferred operation of assigning security codes to the handsets (as shown in block 24 of FIG. 2) is described. Initially, the handset detects that it has been placed in the base charging cradle and send a request for a security code to the base station via RF or through the charge contact at a step 40. Preferably, the request includes a copy of the handset's current (i.e. original) security code. The base station then checks a list of all known handset security codes to determine if it has previously communicated with the handset at a step 42. The base station generates a new random security code at a step 44 and sends it to the handset. The base station then waits to receive an acknowledge signal

from the handset at a step 46 indicating that the new security code has been received.

If the base station does not receive an acknowledge from the handset, the base station then determines if the handset is still in the base station at a step 48. If the handset is in the base station, the base station generates a new random security code at step 44 and sends it to the handset. However, if the handset is not still in the base station, the base station exits at step 50. Alternatively, if the security code is sent by way of RF, the base station generates a new random security code at step 44 as shown by the dotted line if no acknowledge is returned form the handset at step 46.

If the base station receives an acknowledge back from the handset indicating that the new security code has been received from the base station at step 46, the base station checks a list of security codes assigned to handsets in the system to determine if the original security code of the handset is in the list at a step 52. If the original security code is in the list, the base station replaces the original security code with the newly assigned security code at a step 54 and exits at a step 50. However, if the original security code is not in the list, the base station determines if their are any empty slots in the list at a step 56. If there is an empty slot, the base station replaces the empty slot with the new security code at a step 58. However, if there are no remaining empty slots in the base station, the base station replaces the least recently used security code with the new security code on the list at a step 60. Accordingly, the base station will maintain a list of all active handsets within the system. As stated earlier, an identical list of security code is maintained in each of the base stations to allow for communication between each handset and any of the base stations.

Turning now to FIG. 4, the preferred method of maintaining the channel alignment (shown in block 28 of FIG. 2) is described. After having assigned the security codes to the handsets, the method of the present invention maintains a channel alignment

between each handset and a given base station. In particular, a periodic timer expires initiating a channel alignment procedure at a step 70. The handset then randomly selects a channel search pattern with an even distribution of the channels at a step 72. The random distribution of channels is beneficial in a communication system having multiple handsets. In particular, it is a simple method of collision avoidance, should more than one handset be searching simultaneously for a base station for alignment or off hook purposes.

The handset sets the operating channel onto the first channel N in the pattern. Preferably, the first channel in the pattern is set to the channel on which the handset was previously aligned to a base station. This may decrease the time the channel is occupied for this procedure in the event that the handset is still aligned. The handset then sends a request for a handshake to the base via the RF link on channel N at a step 74. The method then determines if there is a base on channel N which is in range at a step 76. If there is a base on channel N which is within range, the handset is aligned with the base. Accordingly, the base sends an acknowledge at step 78. If the handset sees the acknowledge at a step 78, the handset returns to step 70 to wait for the periodic timer to expire to complete another channel alignment.

If there is no base on channel N which is in range at step 76 or the handset does not see the acknowledge from the base at step 80 within a predetermined amount of time, the handset advances the channel number to the next channel in the pattern at a step 82. The handset then determines if all channels in the pattern have been used at a step 84. If all the channels have not been used, the handset sends a request for a handshake to the base via the RF link on a new channel N at a step 74. However, if all the channels in the pattern have been used, the handset returns to step 72 to randomly select a new channel search pattern and begin the channel alignment procedure again. The

handset could optionally align to the base with the highest RSSI level.

Accordingly, the channel alignment procedure described in reference to FIG. 4 maintains a channel alignment of the handset with a base by periodically sending a handshake request to a base on a certain channel, and incrementing the channel if no return handshake is received from the base. The handset will align with a base station even when the handset is moved from one location to another within the range of base stations while onhook.

Turning now to FIG. 5, a flow chart describes the preferred operation of an offhook request (as shown in block 30 of FIG. 2) according to the method of the present invention. In particular, the user initiates a connection at the handset at a step 90. The handset then randomly selects a channel search pattern with an even distribution of channels at a step 92. The handset sets the channel of the handset equal to the first channel N in the pattern. Preferably, the first channel in the pattern is set to the channel which was previously determined during the channel alignment procedure (described in detail in reference to FIG. 4) to reduce the time required to make an offhook connection.

The handset then sends a request to go offhook to the base via the RF link on channel N at a step 94. The handset then determines if there is a base on channel N which is in range at a step 96. If there is a base on channel N which is in range, the handset determines whether the base is already servicing a handset at a step 98. If the base is not already servicing the handset, the base sends an acknowledge signal and goes offhook on channel N at a step 100. If the handset sees an acknowledge at a step 102, the connection is made on channel N at a step 104.

If the base is already servicing a handset, the base ignores the handset request at step 106. Similarly, if there is no base on channel N which is in range at step 96, or the handset does not see an acknowledge at step 102, the handset advances the

channel number to the next one in the pattern at a step 108. If all the channels in the pattern have not been used at a step 110, the handset sends a request to go offhook to the base via the RF link on the next channel in the list at a step 94. However, if all the channels in the pattern have been used, the handset randomly selects a new channel search pattern with an even distribution at a step 92 to begin an offhook request again.

Turning now to FIG. 6, one method for implementing the function of block 32 of FIG. 2 is shown. Having established a connection with a base station, the original base station (i.e. the base station having a connection before any handoff to a new base station) will periodically determine whether a handoff is required by establishing a time-out period at step 120. The original base station will determine if the original base station or handset RSSI has fallen below a certain threshold at a step 122. If the original base station and/or the handset RSSI has fallen below the threshold, the original base station instructs all base stations which are not currently serving a handset to go to its channel at a step 124. The original base station also instructs each base station not currently serving a handset to report (i) the RSSI level of the handset and (ii) the channel which it will be operating on a step 126. All base stations are then instructed to go back to their original channels, and the original base station selects the base station having the highest RSSI signal at a step 128. The original base station also send a "go to channel X" to the handset.

The handset then initiates a handshake with the new base and waits for a return handshake at a step 130. If there is no return handshake, the handset returns to the original base at a step 132. If upon returning, the handset can not re-establish communication with the original base station, the handset will search for a new base station using the same search pattern as described in detail in reference to FIG. 5 for going offhook. However, if there is a return handshake, the new base station sends a hangup command to the original base station at a step

134. Accordingly, if there is base to base communication provided by the TELCO line, an AC line or separate RF communication, it is possible to complete the handoff procedure with little interruption of the communication.

Turning now to FIG. 7, an alternate method for implementing block 32 of FIG. 2 is shown. In particular, a method for handing off in a system having no separate base to base communication is described in reference to FIG. 7. The original base station establishes a certain timeout period at a step 140. If the original base station determines that the original base station and/or handset RSSI level falls below a certain threshold at a step 142, the original base station goes on hold and the handset begins an offhook request at a step 144. The offhook request is identical to the offhook request described in reference to FIG. 5 and will not be repeated again here in detail. If the handset is unable to find another base station at a step 146, the handset returns to the original base station and takes itself off hold with a data message at a step 148. However, if the original base station sees the new base station go off hook by sensing a change in the telco line impedance at a step 150, the original base station hangs itself up.

Turning now to FIG. 8, a preferred circuit for communicating between base stations is shown. A block diagram for base station 10 shows the relevant portions of the base station for providing information signals between the base stations by way of the data link. Each base station generally includes a radio transceiver 220 for transmitting RF communication signals to and receiving RF communication signals from each remote device 12. Radio transceivers well known in the art could be employed in the present invention. Preferably, the radio transceiver circuit disclosed in the aforementioned US Patent 5,140,635 is employed. The RF communication signals include the frequency or channel which the remote device occupies, a security code assigned to the remote device to allow the remote device to operate in the wireless communication system 10, and any

message signals. The message signals may depend on the remote device, but could include voice signals, facsimile data or computer data.

Radio transceiver 220 provides communication signals on a line 222 which is coupled to a signal transceiver circuit 224. Signal transceiver circuit 224 includes a standard telephone company interface (Telco) circuit 226 for transmitting communication signals. Standard Telco circuits are well known in the art and provide communication signals to the standard tip and ring lines of the public system telephone network (PSTN).

Radio transceiver 220 also generates an information signal on a line 222. The information signal could include a receiver signal strength indicator (RSSI) signal and an associated security code for the remote device. The RSSI signal indicates the strength of RF communication signals received from remote device 12. In a system having multiple remote devices, an RSSI signal is generated for each remote device 12 and is identified by the security code associated with the remote device. The RSSI signal could be an on/off indicator or could represent a discrete level within a predetermined range of levels representing the signal strength. Information signals including an RSSI signal are provided to a microprocessor 228.

Microprocessor 228 in each base station 10 maintains an RSSI signal indicating the signal strength of the RF communication signal received from each remote device 12. Microprocessor 228 also communicates with signal transceiver circuit 224 to transmit the RSSI signals to the other base stations and receive RSSI signals from the other base stations by way of data link 14. As will be described in detail in reference to the operation of the circuit of the present invention, microprocessor 228 of each active base station compares the RSSI signals associated with a given remote device from the base stations to determine if another base station is receiving a stronger RF communication signal.

Signal transceiver circuit 224 generally includes a transmitter circuit 230 and a receiver circuit 232. Microprocessor 228 provides an RSSI signal to signal transceiver circuit 224 for coupling signals to the tip and ring lines of the PSTN by way of data link 14. Preferably, transmitter circuit 230 transmits information signals at a frequency of approximately 30 KHz. A frequency of 30 KHz is selected to optimize the transmission of the information signals. In particular, a 30 KHz signal is outside the audible range and will not therefore be heard by the user of the remote device. A 30 KHz signal frequency is also the lowest frequency outside the audible range and, therefore, allows largest signal amplitude on the Telco line. Finally, a 30 KHz signal will be filtered by the public system telephone network. While a 30 KHz signal is preferred, any other frequency which is outside the audible range and which will be filtered by the public system telephone network could be used.

Signal transceiver circuit 224 also includes a receiver circuit 232 for receiving information signals from other base stations by way of data link 14 Preferably, receiver circuit 232 includes a bandpass filter for passing 30 KHZ signals transmitted on the data link by transmitter circuits of other base stations. The information signals are coupled to the microprocessor where they are stored. Because each base station will receive the information signals from the other base stations, any one of the base stations will be able to function as an active base station and determine which base station is receiving the strongest RF communication signal from a particular remote device.

Finally, an answering machine 233 may be incorporated in one of the base stations. Preferably, the answering machine will be a digital answering machine.

Turning now to FIG. 9, the preferred signal transceiver circuit 224 (shown in block form in FIG. 8) found in each base station 11 is shown in detail. Transmitter circuit 230 includes an AND gate 234 having a first input 236 coupled to receive a 30 KHz square wave and a second input 238 coupled to receive

data. The data should include information signals describing the remote device, the channel or frequency of operation, and the RSSI signal generated by the radio transceiver as described above. The data will be transmitted as a 30 KHz square wave by ANDING the data with the 30 KHz square wave signal. Alternatively, the data could be provided by the microprocessor as a 30 KHz signal. The output 240 of AND gate 234 is coupled by a capacitor 242 to the TIP line. Preferably, capacitor 242 is approximately 200 picofarads. Output 240 of AND gate 234 is also coupled to an inverter 244. The output 246 of inverter 244 is coupled by a capacitor 248 to the RING line. Capacitor 248 is also preferably 200 picofarads.

Telco circuit 226 is also shown in detail in FIG. 9. Telco circuit 226 includes a transformer 252 for transmitting and receiving audio signals from the radio transceiver. The transformer is coupled to a relay 254. Relay 254 is controlled by a transistor 256 which is turned on or off by a voltage at a control electrode 258 coupled to an input resistor 260. Relay 254 is coupled to a bridge circuit 262 at a node 264. Nodes 266 and 268 of bridge circuit 262 are coupled to the TIP and RING lines. Bridge circuit 262 also receives signals from the TIP and RING lines at nodes 266 and 268. Finally, node 270 is coupled to transformer 252 for transmitting signals from the TIP and RING lines to the radio transceiver.

Finally, signal transceiver circuit 224 includes a receiver circuit 270. The receiver circuit acts as a bandpass filter to pass the information signals from the other base stations, and block signals from the public system telephone network. Preferably, receiver circuit 270 will pass 30 KHz information signals which are transmitted by the transmitter circuits 230 of the other base stations.

Receiver circuit 270 includes a differential amplifier circuit 272 having a positive input 274 and a negative input 276. Positive input 274 is coupled to the RING line by a capacitor 278 and resistor 280 which form a low pass filter. Preferably capacitor

278 is 620 pf and resistor 280 is 10 KΩ. Input 274 is also coupled to a parallel RC network comprising a capacitor 282 and a resistor 284 to form a high pass filter. Preferably, capacitor 282 is 20 pf and resistor 284 is 220 KΩ. Negative input 276 to the differential amplifier is also coupled to a capacitor 286 in series with a resistor 288 to form a low pass filter. Preferably, capacitor 286 is 620 pf and resistor 288 is 220 KΩ. Also, a parallel configuration of a capacitor 290 and a resistor 292 is coupled between negative input 276 and the output 294 of the differential amplifier. Preferably, capacitor 290 is 20 pf and resistor 292 is 220 KΩ.

The detailed signal transceiver circuit 224 shown FIG. 9 is one example of a circuit which could be employed. However, it will be understood that other signal transceiver circuits for transmitting and receiving approximately 30 KHz information signals on the data link could be employed within the scope of the present invention.

In summary, the present invention establishes and maintains communication in a portable telephone system adapted to operate with a plurality of base stations and at least one handset on a plurality of channels. The method generally assigns security codes to the handset(s) operating in the portable communication system, and provides copies of the security codes to each of the base stations to enable RF communication between the handset(s) and the base stations. The method also aligns the channel of the handset(s) with a channel of a base station to allow for communication between each handset and one of the plurality of base stations. In particular, when a particular handset is not in use, the method mainitains a channel alignment with a base station within range. Further, during RF communication with a handset, a base station will handoff between base stations to maintain communication. Such a handoff could be provided by communication between the bases.

Claims

1. A method for establishing and maintaining communication in a portable radio telephone system including a plurality of base stations adapted to communicate via a plurality of radio channels with at least one remote device, said method comprising the steps of:

assigning a security code to the at least one remote device to enable communication between the at least one remote device and the plurality of base stations;

communicating the security code assigned to the at least one remote device to the plurality of base stations to maintain within each of the plurality of base stations the security code of the at least one remote device operating in the system; and

aligning the radio channel of the at least one remote device with the radio channel of one of the plurality of base stations to allow for communication between the at least one remote device and at least one of the plurality of base stations.

2. The method for establishing and maintaining communication in a portable radio communication system of Claim 1 adapted to operate with a plurality of remote devices, wherein the step of assigning a security code includes assigning a distinct security code to each of the plurality of remote devices.

3. The method for establishing and maintaining communication in a portable radio communication system of Claim 1 adapted to operate with a plurality of remote devices, wherein the step of communicating the security code includes generating a list of security codes for the plurality of remote devices in each of the plurality of base stations.

4. The method for establishing and maintaining communication in a portable radio communication system of Claim 1 wherein the step of assigning a security code includes the steps of:

providing the current security code of the remote device to a base station;

assigning a new security code to the remote device; and

placing the new security code on the master list of security codes.

5. The method for establishing and maintaining communication in a portable radio communication system of Claim 4 wherein the steps of providing the current security code and assigning a new security code are accomplished by RF communication.

6. A method for assigning security codes for a portable radio communication system including a plurality of remote devices adapted to communicate via at least one radio channel with at least one base station comprising the steps of:

providing the current security code of each of the plurality of remote devices;

assigning a new security code to each of the plurality of remote devices; and

placing each new security code on the master list of security codes in the at least one base station.

7. A method of maintaining communication with a remote device in a radio communication system including at least one base station adapted to communicate on a plurality of radio channels with at least one remote device, said method comprising the steps of:

periodically sending a handshake request from the at least one remote device to the at least one base station;

waiting for a return handshake from the at least one base station; and

changing the channel of the at least one remote device to correspond to the channel of the at least one base station which returned the handshake.

8. The method of maintaining communication with a remote device of Claim 7 adapted to operate with a plurality of bases stations wherein the plurality of base stations are maintained on different channels.

9. A method for maintaining communication in a portable radio communication system including a plurality of base stations adapted to communicate on a plurality of radio channels with at least one remote device, said at least one remote device being in active communication with one base stations of said plurality of base stations, said method comprising the steps of:

evaluating the receiver signal strength indicator level of said signal received at said one base station from said at least one remote device;

said one base station instructing remaining base stations to report receiver signal strength indicator level and an operating channel;

selecting the base station reporting the strongest receiver signal strength indicator signal;

instructing said remote device to switch to said operating channel; and

providing a handshake between the remote device and the base station reporting the strongest receiver signal strength indicator signal.

10. A method for maintaining communication in a portable radio communication system including a plurality of base stations adapted to communicate via a plurality of radio communication channels with at least one remote device, said at least one remote device being in active communication with one base stations of said plurality of base stations, said method comprising the steps of:

evaluating the receiver signal strength indicator level of said signal received at said one base station from said at least one remote device;

placing said one base station on hold;

requesting said at least one remote device to make a connection to said base station reporting the strongest receiver signal strength indicator signal;

providing a handshake between said at least one remote device and said base station reporting the strongest receiver signal strength indicator signal.

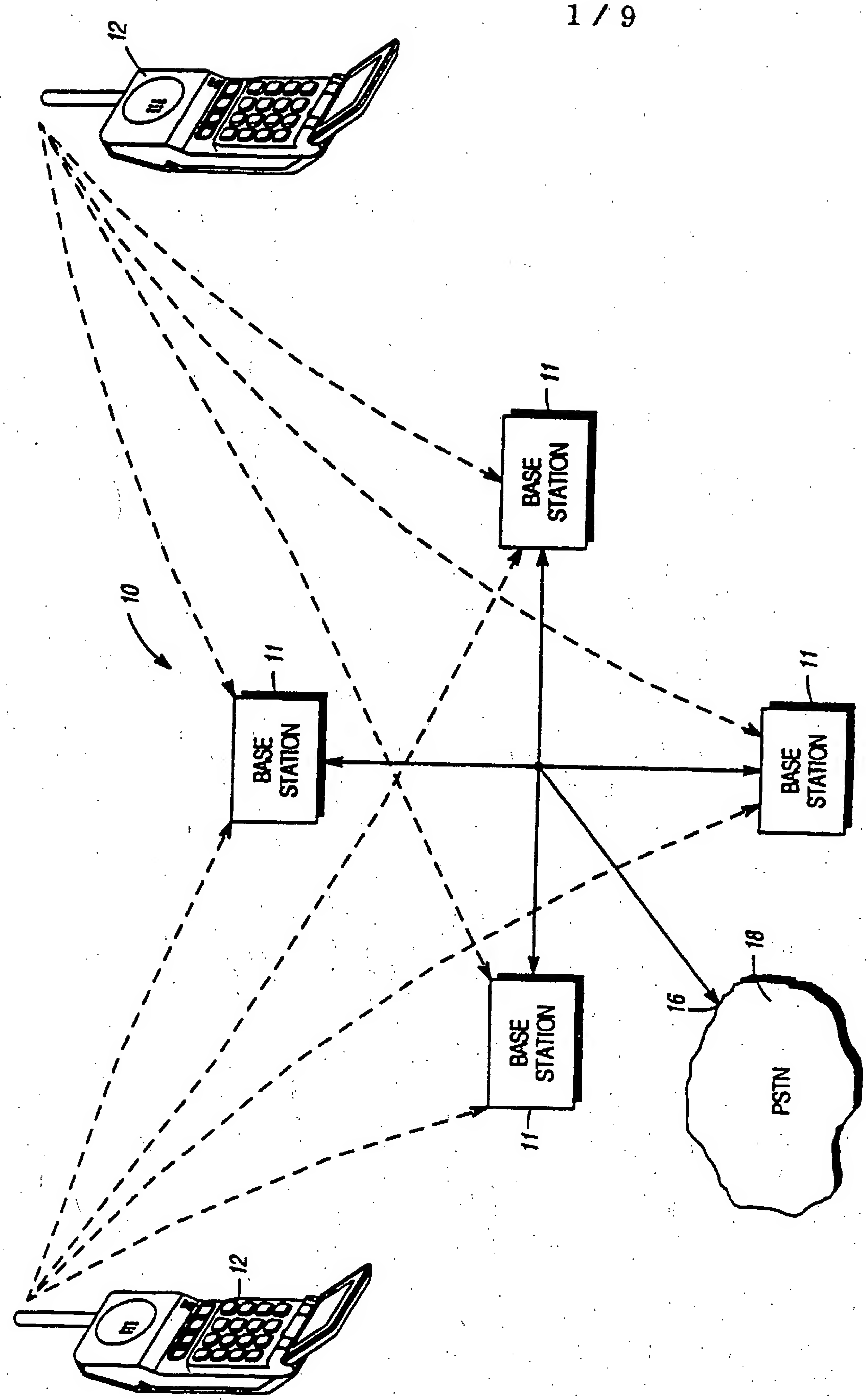

12
10
11
BASE STATION
BASE STATION
BASE STATION
BASE STATION
11
11
11
16
18
PSTN
12

FIG.1

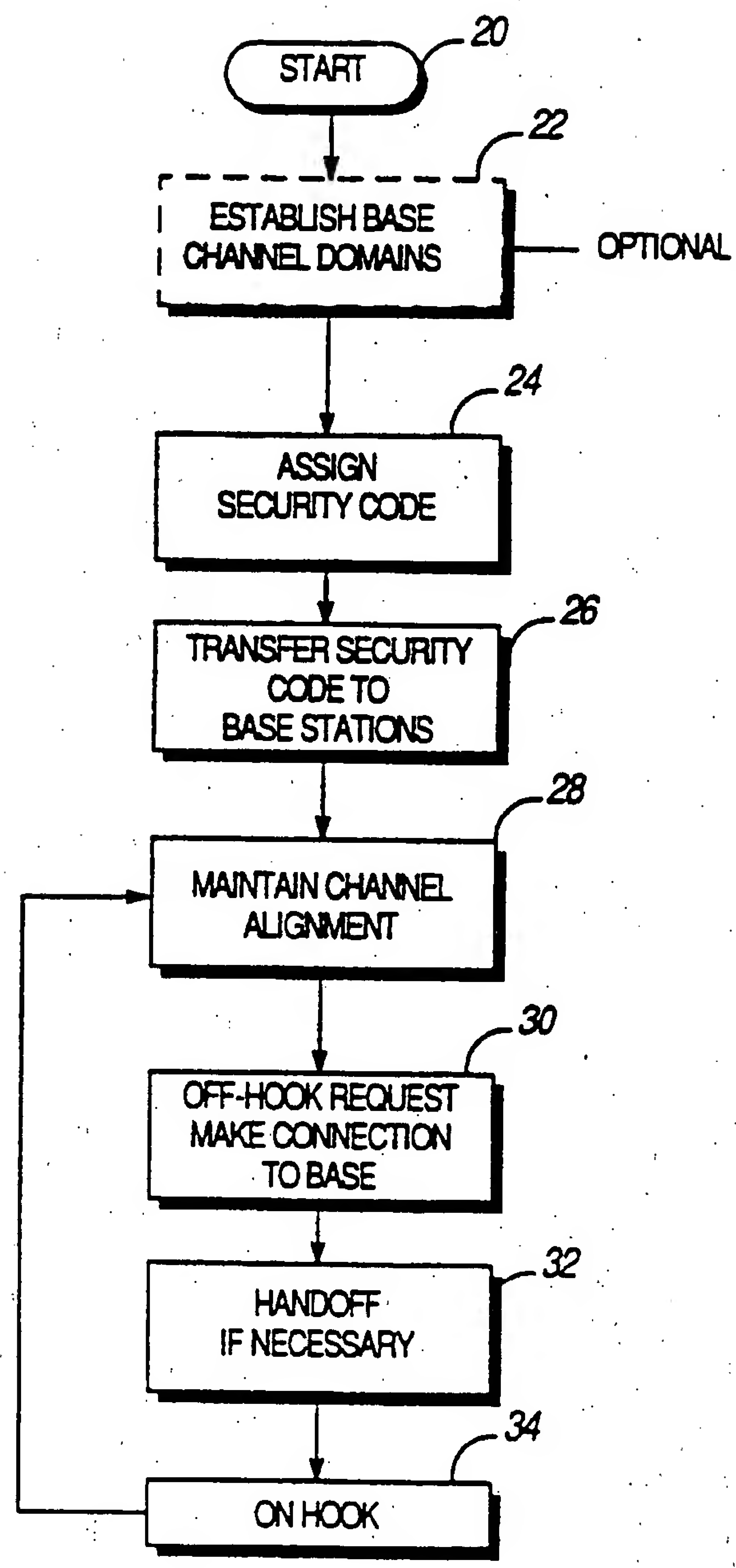
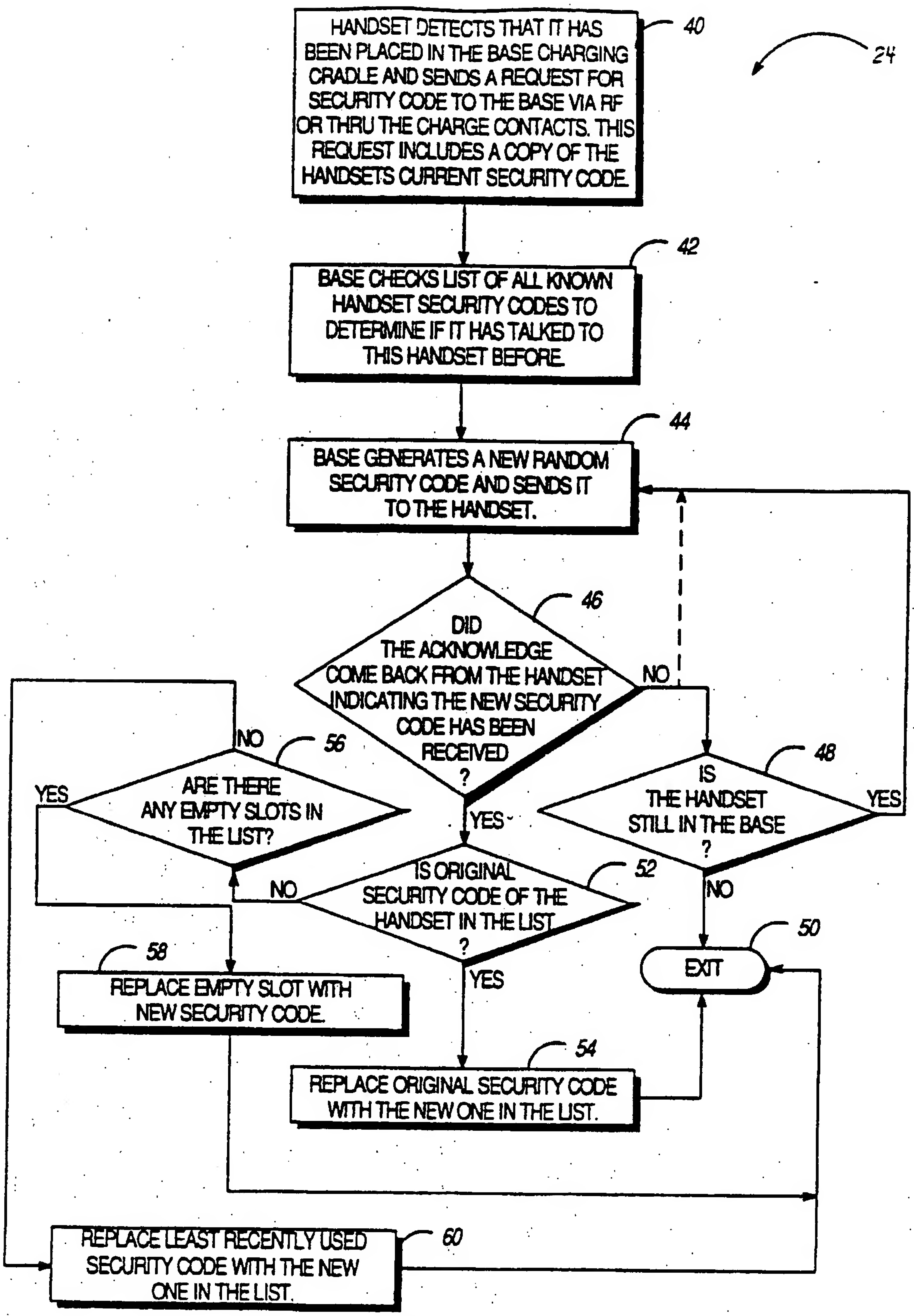
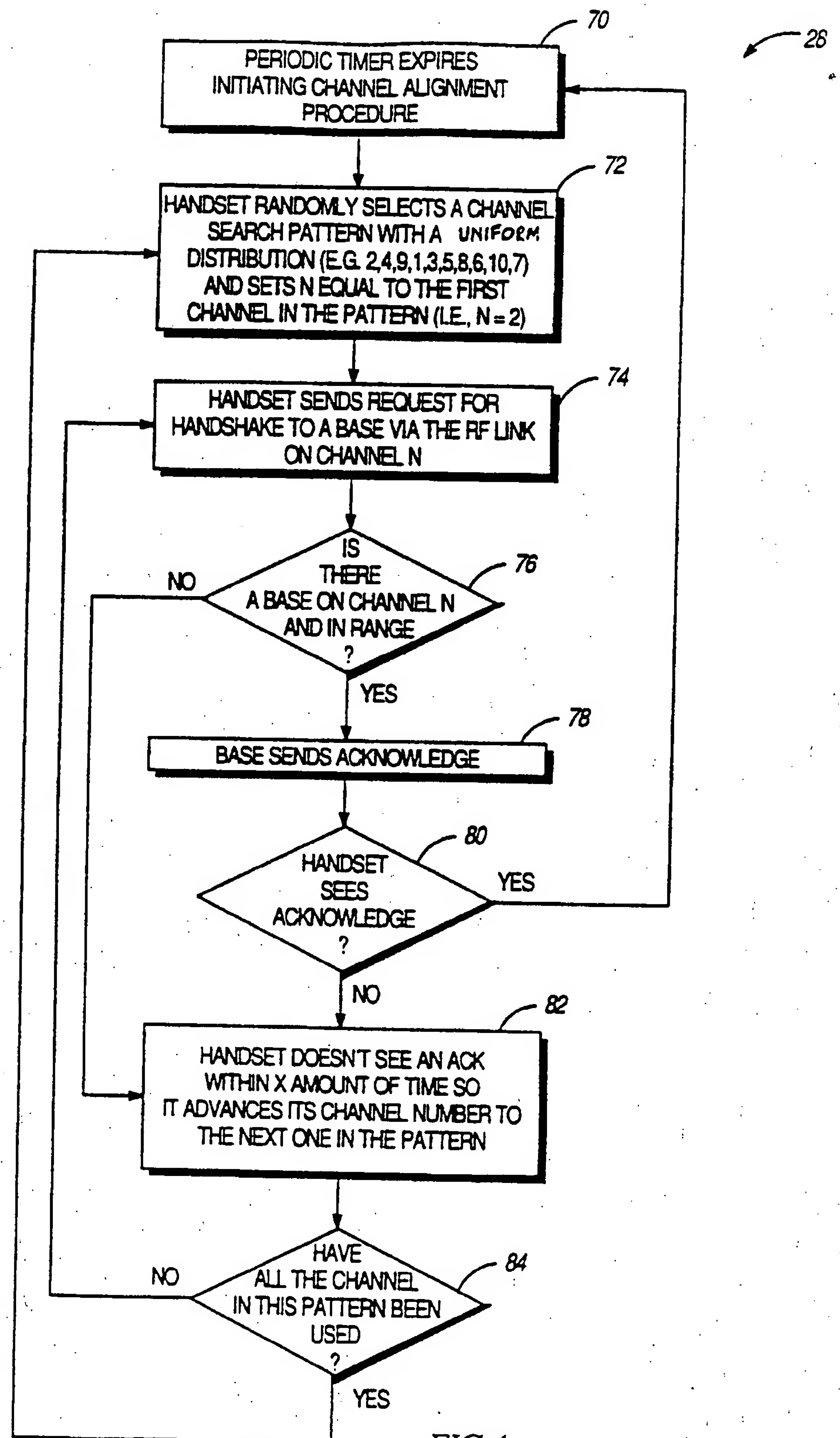

START
20
ESTABLISH BASE CHANNEL DOMAINS
22
OPTIONAL
ASSIGN SECURITY CODE
24
TRANSFER SECURITY CODE TO BASE STATIONS
26
MAINTAIN CHANNEL ALIGNMENT
28
OFF-HOOK REQUEST MAKE CONNECTION TO BASE
30
HANDOFF IF NECESSARY
32
ON HOOK
34

FIG.2



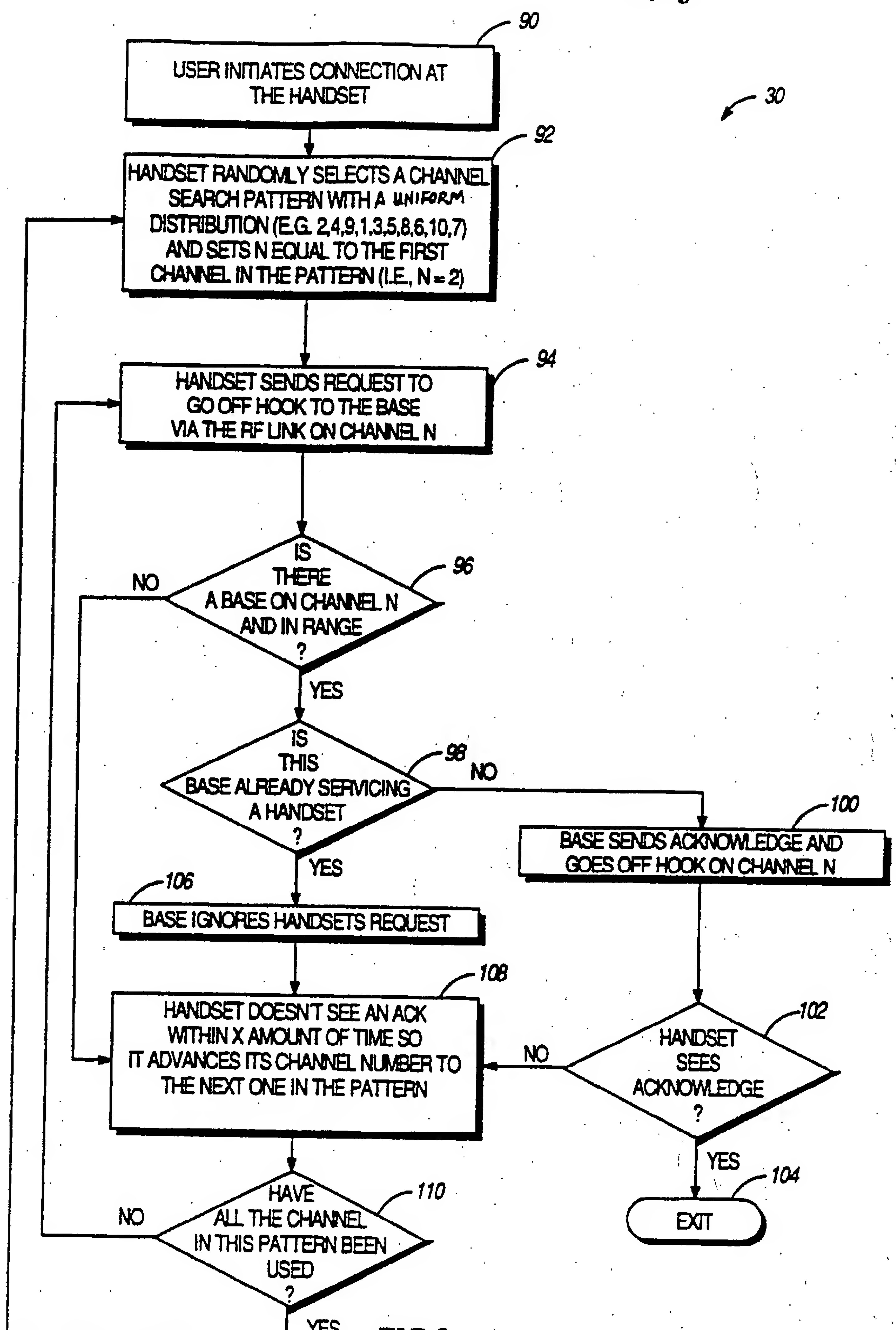
HANDSET DETECTS THAT IT HAS BEEN PLACED IN THE BASE CHARGING CRADLE AND SENDS A REQUEST FOR SECURITY CODE TO THE BASE VIA RF OR THRU THE CHARGE CONTACTS. THIS REQUEST INCLUDES A COPY OF THE HANDSETS CURRENT SECURITY CODE.
40
24
BASE CHECKS LIST OF ALL KNOWN HANDSET SECURITY CODES TO DETERMINE IF IT HAS TALKED TO THIS HANDSET BEFORE.
42
BASE GENERATES A NEW RANDOM SECURITY CODE AND SENDS IT TO THE HANDSET.
44
DID THE ACKNOWLEDGE COME BACK FROM THE HANDSET INDICATING THE NEW SECURITY CODE HAS BEEN RECEIVED ?
46
NO
YES
IS THE HANDSET STILL IN THE BASE ?
48
YES
NO
EXIT
50
ARE THERE ANY EMPTY SLOTS IN THE LIST?
56
NO
YES
IS ORIGINAL SECURITY CODE OF THE HANDSET IN THE LIST ?
52
NO
YES
REPLACE EMPTY SLOT WITH NEW SECURITY CODE.
58
REPLACE ORIGINAL SECURITY CODE WITH THE NEW ONE IN THE LIST.
54
REPLACE LEAST RECENTLY USED SECURITY CODE WITH THE NEW ONE IN THE LIST.
60

FIG.3



70
26
PERIODIC TIMER EXPIRES INITIATING CHANNEL ALIGNMENT PROCEDURE
72
HANDSET RANDOMLY SELECTS A CHANNEL SEARCH PATTERN WITH A UNIFORM DISTRIBUTION (E.G. 2,4,9,1,3,5,8,6,10,7) AND SETS N EQUAL TO THE FIRST CHANNEL IN THE PATTERN (I.E., N=2)
74
HANDSET SENDS REQUEST FOR HANDSHAKE TO A BASE VIA THE RF LINK ON CHANNEL N
76
IS THERE A BASE ON CHANNEL N AND IN RANGE ?
NO
YES
78
BASE SENDS ACKNOWLEDGE
80
HANDSET SEES ACKNOWLEDGE ?
YES
NO
82
HANDSET DOESN'T SEE AN ACK WITHIN X AMOUNT OF TIME SO IT ADVANCES ITS CHANNEL NUMBER TO THE NEXT ONE IN THE PATTERN
84
HAVE ALL THE CHANNEL IN THIS PATTERN BEEN USED ?
NO
YES

FIG.4



90
30
USER INITIATES CONNECTION AT THE HANDSET
92
HANDSET RANDOMLY SELECTS A CHANNEL SEARCH PATTERN WITH A UNIFORM DISTRIBUTION (E.G. 2,4,9,1,3,5,8,6,10,7) AND SETS N EQUAL TO THE FIRST CHANNEL IN THE PATTERN (I.E., N=2)
94
HANDSET SENDS REQUEST TO GO OFF HOOK TO THE BASE VIA THE RF LINK ON CHANNEL N
96
IS THERE A BASE ON CHANNEL N AND IN RANGE ?
NO
YES
98
IS THIS BASE ALREADY SERVICING A HANDSET ?
NO
YES
100
BASE SENDS ACKNOWLEDGE AND GOES OFF HOOK ON CHANNEL N
106
BASE IGNORES HANDSETS REQUEST
108
HANDSET DOESN'T SEE AN ACK WITHIN X AMOUNT OF TIME SO IT ADVANCES ITS CHANNEL NUMBER TO THE NEXT ONE IN THE PATTERN
102
HANDSET SEES ACKNOWLEDGE ?
NO
YES
104
EXIT
110
HAVE ALL THE CHANNEL IN THIS PATTERN BEEN USED ?
NO
YES

FIG.5

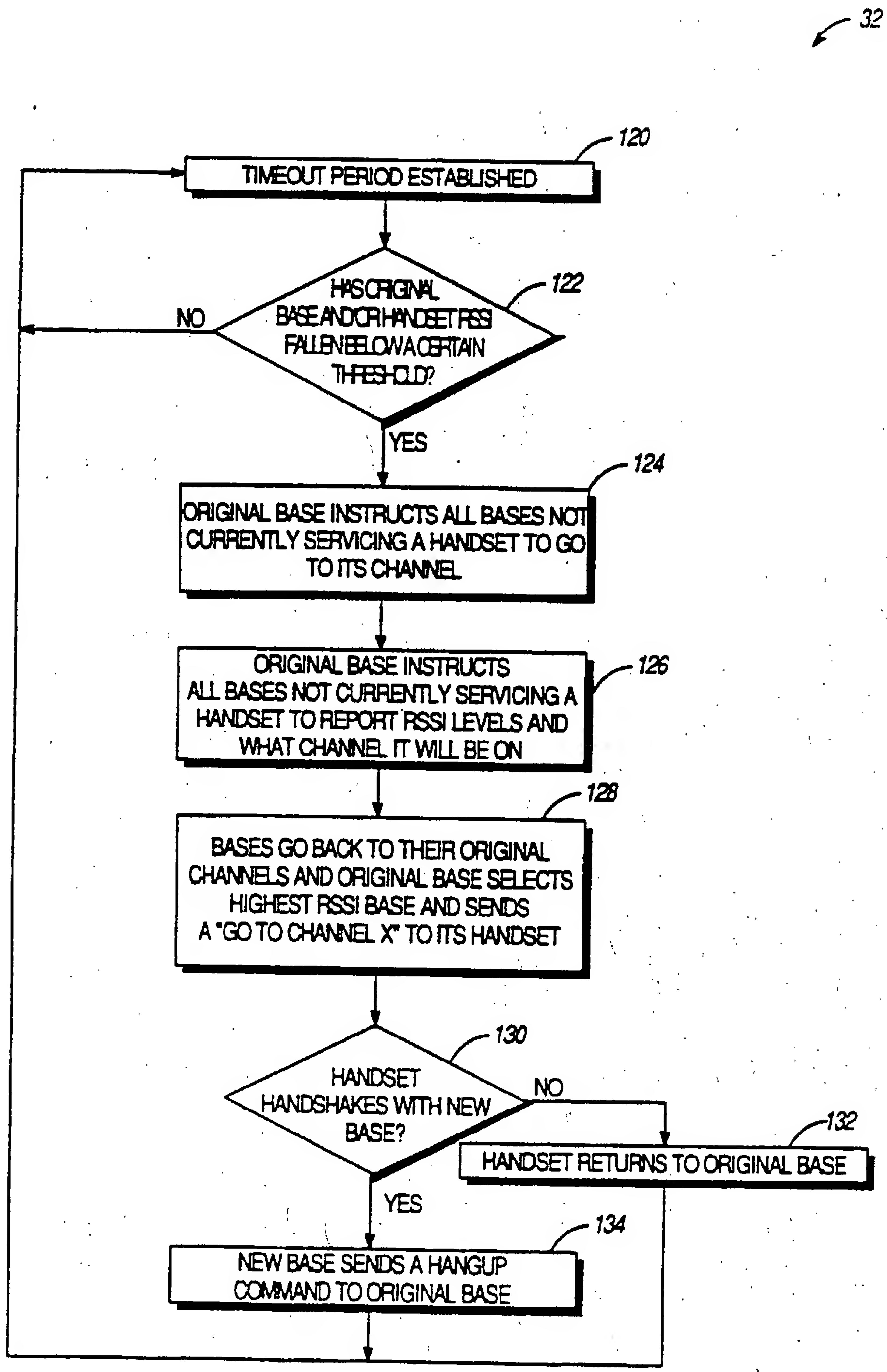

32
120
TIMEOUT PERIOD ESTABLISHED
122
HAS ORIGINAL BASE AND/OR HANDSET RSSI FALLEN BELOW A CERTAIN THRESHOLD?
NO
YES
124
ORIGINAL BASE INSTRUCTS ALL BASES NOT CURRENTLY SERVICING A HANDSET TO GO TO ITS CHANNEL
126
ORIGINAL BASE INSTRUCTS ALL BASES NOT CURRENTLY SERVICING A HANDSET TO REPORT RSSI LEVELS AND WHAT CHANNEL IT WILL BE ON
128
BASES GO BACK TO THEIR ORIGINAL CHANNELS AND ORIGINAL BASE SELECTS HIGHEST RSSI BASE AND SENDS A "GO TO CHANNEL X" TO ITS HANDSET
130
HANDSET HANDSHAKES WITH NEW BASE?
NO
132
HANDSET RETURNS TO ORIGINAL BASE
YES
134
NEW BASE SENDS A HANGUP COMMAND TO ORIGINAL BASE

FIG.6

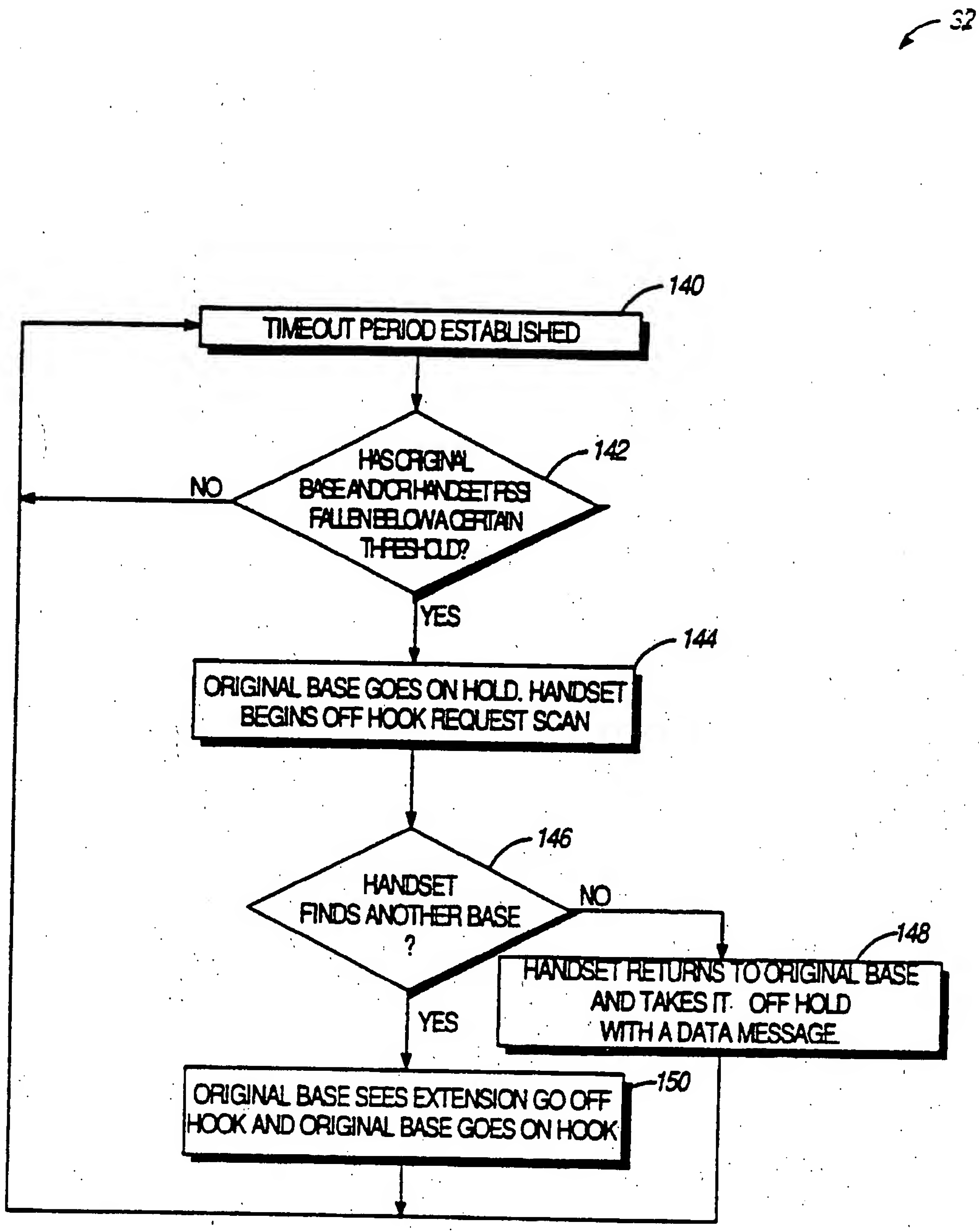

32
140
TIMEOUT PERIOD ESTABLISHED
142
HAS ORIGINAL BASE AND/OR HANDSET RSSI FALLEN BELOW A CERTAIN THRESHOLD?
NO
YES
144
ORIGINAL BASE GOES ON HOLD. HANDSET BEGINS OFF HOOK REQUEST SCAN
146
HANDSET FINDS ANOTHER BASE ?
NO
148
HANDSET RETURNS TO ORIGINAL BASE AND TAKES IT OFF HOLD WITH A DATA MESSAGE
YES
150
ORIGINAL BASE SEES EXTENSION GO OFF HOOK AND ORIGINAL BASE GOES ON HOOK

FIG.7

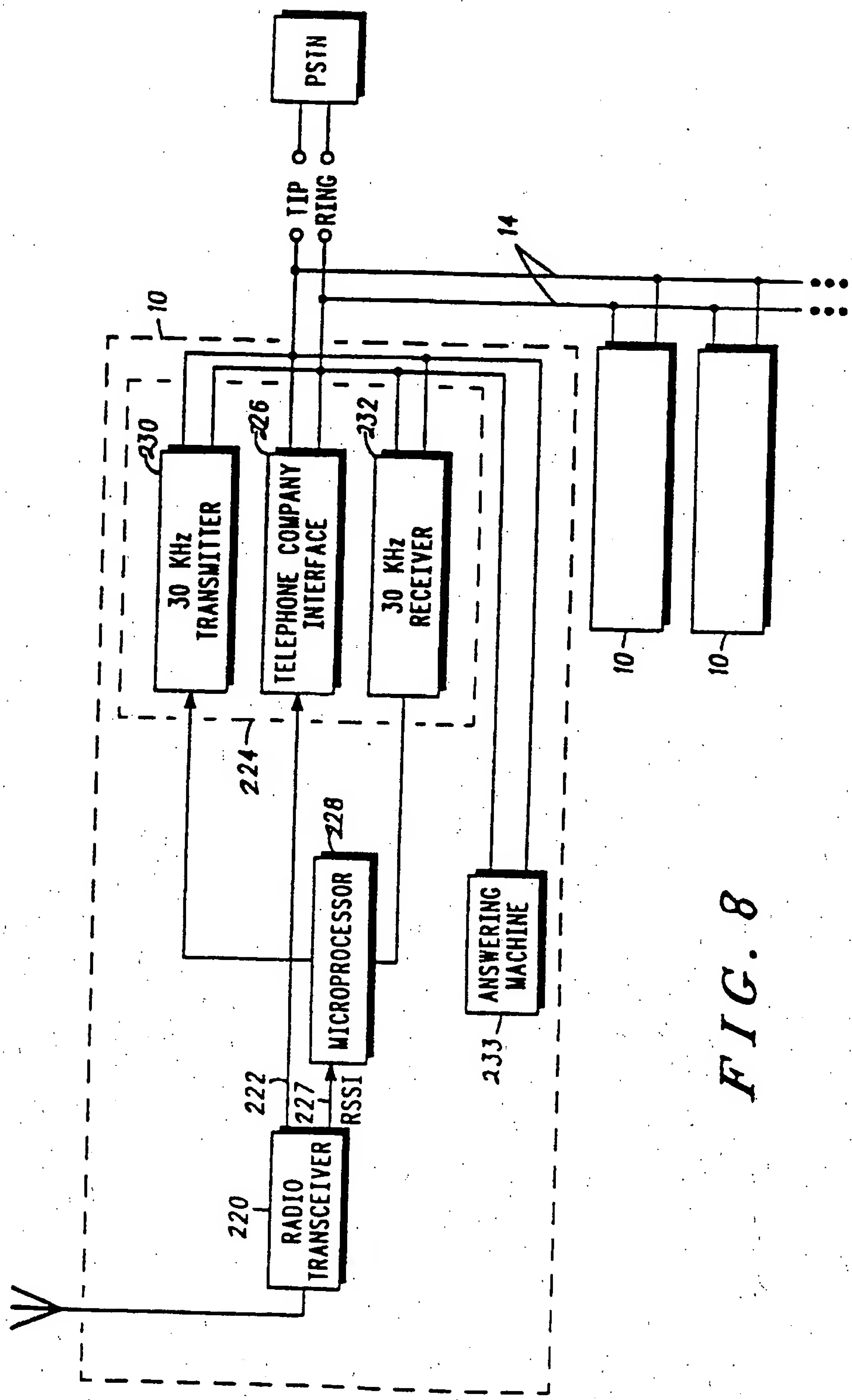
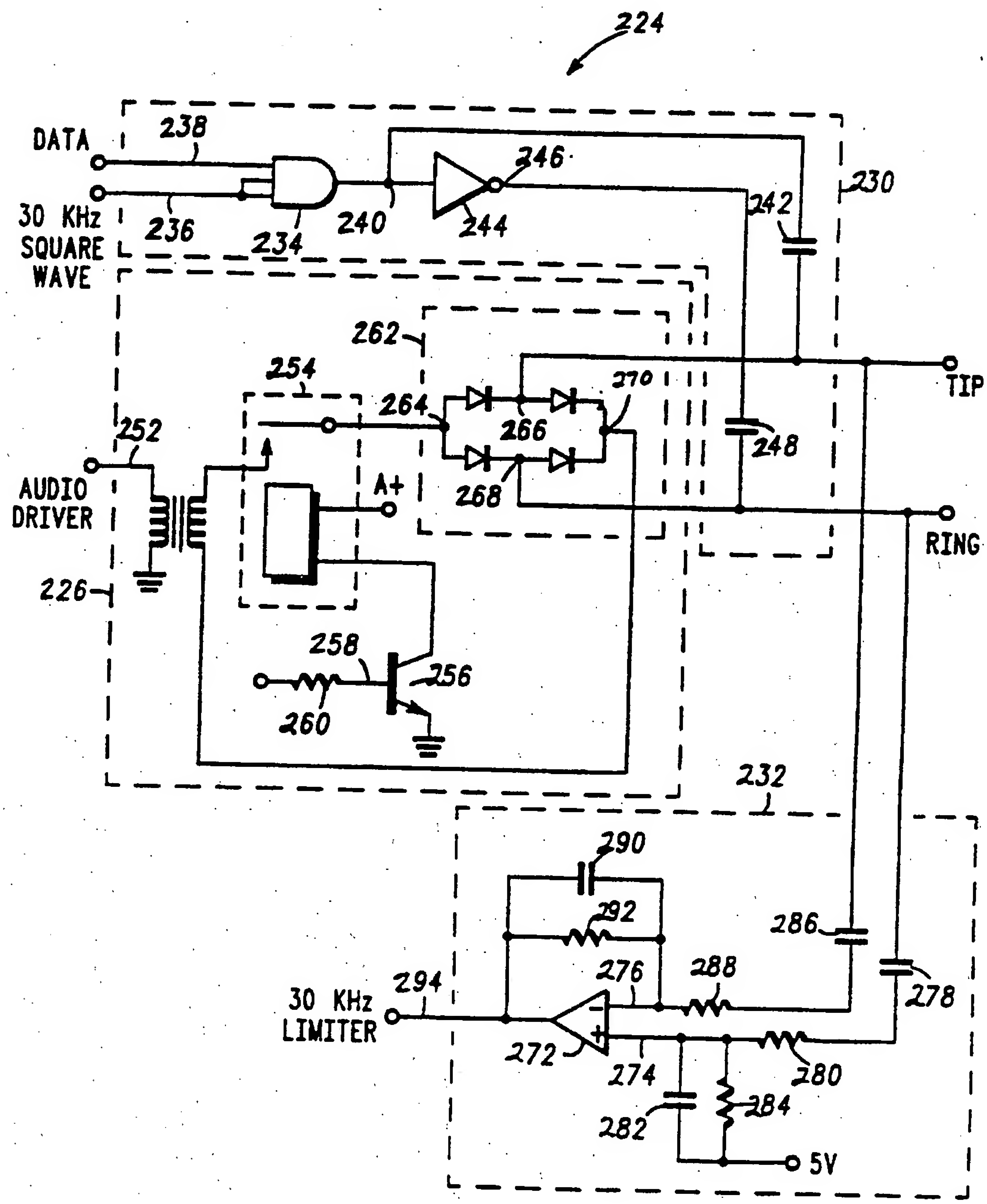

PSTN
TIP
RING
14
10
30 KHz TRANSMITTER
230
TELEPHONE COMPANY INTERFACE
226
30 KHz RECEIVER
232
10
10
224
228
MICROPROCESSOR
ANSWERING MACHINE
233
222
227
RSSI
220
RADIO TRANSCEIVER

FIG. 8

FIG. 9


224
DATA
238
246
230
30 KHz SQUARE WAVE
236
234
240
244
242
262
254
264
270
266
248
TIP
252
AUDIO DRIVER
A+
268
RING
226
258
256
260
232
290
292
286
276
288
294
30 KHz LIMITER
278
272
274
280
284
282
5V

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/06561

A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) :H04N 11/00
US CL :379/58, 62; 455/34.2
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 379/58, 62, 60; 455/33.2, 56.1, 34.1, 34.2

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 4,901,340 (PARKER ET AL.) 13 FEBURARY 1990, column 5, lines 26-46	1-8
Y,E	US, A, 5,353,331 (EMERY ET AL.) 04 NOVEMBER 1994, column 4, line 46 to column 5, line 65	1-8
Y	US, A, 4,864,599 (SAEGUSA ET AL.) 05 SEPTEMBER 1989, column 2, line 23 to column 4, line 28	1-8
Y	US, A, 5,195,127 (ICHIKAWA ET AL.) 16 MARCH 1993, column 3, line 40 to column 4, line 45	1-8
Y	US, A, 4,953,198 (DALY ET AL.) 28 AUGUST 1990, column 1, line 48 to column 2, line 32 and column 3, lines 20-54	7,8

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be part of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 OCTOBER 1994	30 NOV 1994

Name and mailing address of the ISA/US
Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231
Facsimile No. (703) 305-3230

Authorized officer
Thomas L. Stoll
Telephone No. (703) 305-4857

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/06561

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 4,593,155 (HAWKINS) 03 JUNE 1986 column 5, line 38 to column 8, line 27	7,8
Y	US, A, 5,142,534 (SIMPSON ET AL.) 25 AUGUST 1992, column 14, lines 35-63	9-10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/06561

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Telephone Practice

I. Claims 1-8 drawn to using security codes to indentify remote units in a mobile telephone system, Class 379/62.

II. Claims 9-10 drawn to signal strength for selecting a base unit for handoff, Class 379/60.

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☒ No protest accompanied the payment of additional search fees.